Natural Resource Inventory

and

Long-Term Ecological Monitoring Plan:

Great Plains Prairie Cluster

August 1994

Effigy Mounds National Monument
Iowa

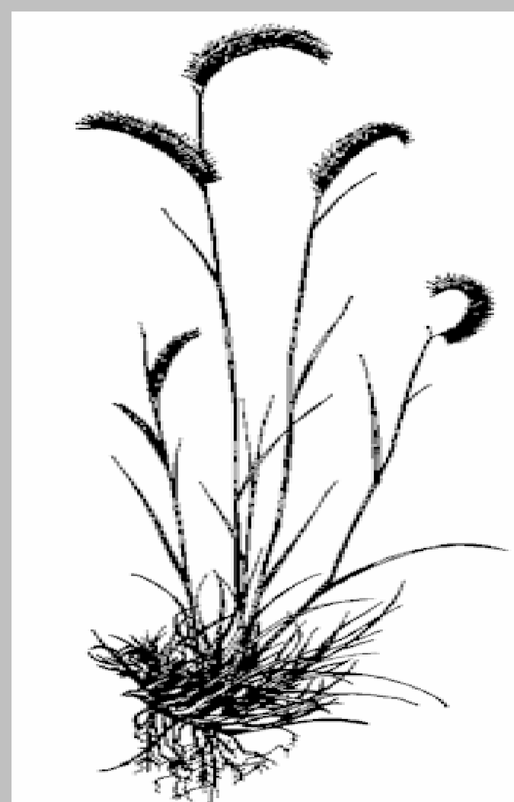
Wilson's Creek National Battlefield
Missouri

Pipestone National Monument
Minnesota

Homestead National Monument
Nebraska

Agate Fossil Beds National Monument
Nebraska

Scotts Bluff National Monument
Nebraska



Bouteloua gracilis
blue grama grass

NATIONAL PARK SERVICE □ NATIONAL BIOLOGICAL SURVEY
• U.S. Department of the Interior •

Contents

Approvals

Superintendent, Effigy Mounds NM Date

Superintendent, Homestead NM Date

Superintendent, Pipestone NM Date

Superintendent, Scotts Bluff/Agate Fossil Beds NM Date

Superintendent, Wilson's Creek NB Date

Regional Director, Midwest Region Date

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Illustrations

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Summary

We propose a long-term monitoring program for a cluster of five small prairie parks. This program focuses on issues identified in a comprehensive survey of natural resources within 32 parks in the Great Plains and the specific inventory and monitoring issues identified in park Resource Management Plans (RMPs). The cluster parks capture much of the biotic diversity of the Great Plains and reflect common concerns faced by small parks. These parks contain high quality to degraded prairie and savanna sites with a range of management histories. The five cluster parks have completed significant natural resource inventories and have developed a number of monitoring protocols.

The overall goal is to develop and/or implement monitoring protocols for resources likely to be enhanced or alternately suppressed by active management and/or external park threats. The proposed protocols relate to three high priority issues: 1) external threats, 2) ecosystem restoration and management, and 3) biological diversity. Altered water quality is the most immediate, external threat facing the cluster parks and will be an early focus of monitoring. Urban encroachment, and concomitant habitat fragmentation are another emphasis of the monitoring program, and will be monitored at the landscape, community and population levels. Monitoring restoration and management will answer the practical question of whether specific management methods are working, and will also allow the National Park Service to contribute to the developing fields of restoration ecology and conservation biology.

We propose a monitoring organization which enhances an existing park-based, prairie restoration program funded by Natural Resource Preservation Program (NRPP). Program costs are reasonable yet conservative. We will ensure scientific credibility of the proposed monitoring in two ways. First, we will continue and, where practicable, enhance working relationships (partnerships) within the NPS and with academic institutions and other private groups and government agencies. Second, we will develop a comprehensive decision support framework for the purpose of integrating results into managerial decision-making. Monitoring results will be distributed to a wide range of audiences including all 32 prairie parks in the Great Plains.

The monitoring program will answer the question that all small parks must address: To what extent are the species, communities and processes under their stewardship sustainable?

I. Introduction

Great Plains Prairie Parks

The Great Plains of North America are broadly defined as the area of grassland or former grassland extending from the Canadian to the Mexican borders and from the foothills of the Rocky Mountains to western Indiana. This area encompasses portions of the Midwest, Rocky Mountain, and Southwest regions of the National Park System. Within the Great Plains, thirty-two national parks have prairie resources (Stubbendieck and Willson 1987) (Figure 1).

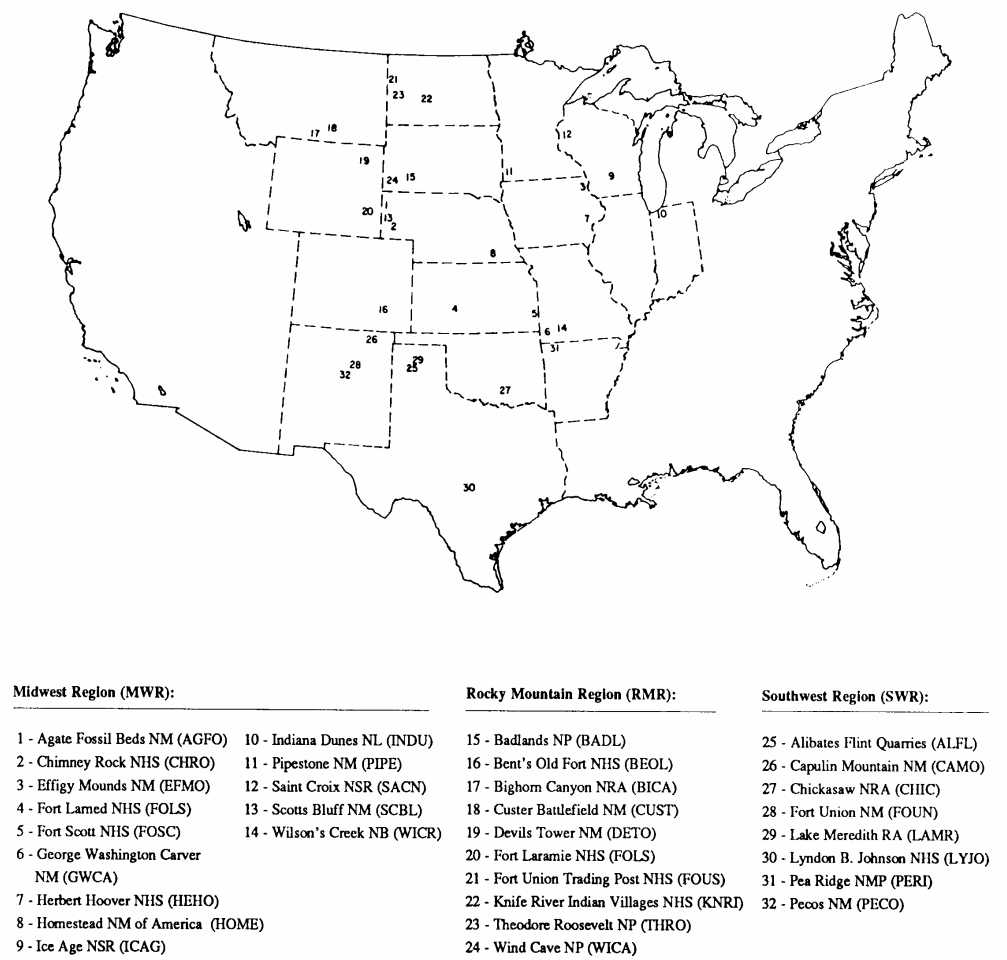

FIGURE 1. Prairie parks in the Great Plains.

The thirty-two Great Plains National Park System Units have about 110,540 ha (273,144 acres) of prairie (Stubbendieck and Willson 1987) (Table 1). Twenty-seven parks contain at least some native prairie and ten parks have restored prairie. Twelve parks contain formerly cultivated or grazed land now undergoing secondary succession (go-back land). By far the largest park is Badlands National Park in South Dakota with more than 69,000 ha (170,499 acres) of native mixed-grass prairie. Pea Ridge National Military Park in Arkansas is the smallest with about 1 ha (2.5 acres) of restored tallgrass prairie. The average size of prairie within these cultural parks is less than 230 ha (568 acres).

Most parks in the Great Plains are historic sites established primarily to preserve cultural resources or to commemorate historic subjects or events. However, the historic scene of these sites - the prairie landscape and the native plant and animal life - constitute an important resource. For example, the enabling legislation for SCBL provides for the protection of the landmark bluff and surrounding prairie as seen by pioneers on the Oregon Trail.

A Great Plains Prairie Cluster

Prairie is often defined as a natural plant community dominated by grasses. Although prairie vegetation is generally of great uniformity to the casual observer, significant differences occur in species composition over the Great Plains. The decreasing moisture from east to west is accompanied by changes in the dominant plant species. As a result, three major prairie subregions are distinguishable by climate and/or vegetation: short grass prairie in the west, tallgrass prairie in the east, and mixed grass prairie in the middle (Risser et al. 1981).

Temperature patterns in the Great Plains also demonstrate significant variation. In the southern part of the Great Plains maximum temperatures of 38°C are not uncommon. At the northern limit of the Great Plains temperatures of -25°C have been recorded. Thus, differences in vegetation also exist on a north/south gradient (Diamond and Smeins 1988).

The climate, soils, and topography of the Great Plains are suitable for agriculture, and most of the original grasslands have been converted to row crops or pasture. It is estimated that less than 1% of the original grasslands remain (Klopatek et al. 1979).

At the eastern border of the Great Plains a band of oak savanna marks the transition from prairie to eastern deciduous forest. Savannas are defined by open-grown trees, growing as scattered individuals or in small groves, with an herbaceous, primarily grassy understory (Bray 1955). While at the time of settlement, oak savanna occupied 11,000,000 to 13,000,000 ha of the midwestern landscape, today less than 3,000 ha of high quality savanna remain (Nuzzo 1986). The Nature Conservancy has ranked tallgrass savanna as a globally endangered community type, and recent attention has focused on developing a recovery plan for oak savanna ecosystems (Midwest Oak Savanna Conference 1993). Prior to settlement, a patchwork of prairie, savanna and woodland occurred in this transition zone, with local variation in soils and topography influencing boundaries between community types (Anderson 1983). Long-term climatic change periodically shifted the width and position of the savanna transition zone. Historically, fires played an important role in maintaining both prairies and savannas under climatic conditions capable of supporting woody vegetation (Anderson 1983).

Table 1. Prairie size and origin (native, restored, go-back) within NPS units and regions in the Great Plains.

Unit	Prairie Size (ha)	Native Prairie	Restored Prairie	Go-Back Land
MWR*				
AGFO	1115	X		
CHRO	26	X		
EFMO	28	X	X	X
FOLS	130	X	X	
FOSC	2		X	
GWCA	22	X	X	
HEHO	31		X	
HOME	38	X	X	
ICAG	6	X		
INDU	400	X		
PIPE	105	X		X
SCBL	875	X	X	X
SACM	20	X		
WICR	59		X	
Total	2857			
RMR				
BADL	69231	X	X	X
BEOL	258	X		X
BICA	632	X		
FOUS	71	X		X
KNRI	304	X		X
THRO	17409	X		X
WICA	9393	X		X
Total	98094			

Table 1 continued.

SWR				
ALFL	526	X		
CAMO	89	X		
CHIC	547	X		X
FOUN	289	X		
LAMR	8097	X		
LYJO	23			X
PERI	1		X	
PECO	16	X		X
Total	9588			
Grand Total	110,539			

*See Figure 1 for an explanation of unit and region codes.

No single NPS unit encompasses the variability inherent in Great Plains ecosystems. Therefore, we propose a prototype long-term inventory and monitoring program based on a cluster of five geographically separated parks (EFMO, HOME, PIPE, SCBL/AGFO[2], WICR). A general description of each park including a map is presented in Appendix A. Prairie areas are designated on the maps. Located along a east-west precipitation gradient and a north-south temperature gradient, these parks capture much of the climatic and biotic variability of all parks in the Great Plains. The cluster contains a mix of short to mid-grass prairie (SCBL/AGFO), tallgrass prairie (HOME, PIPE) and savanna sites (EFMO, WICR) with both high quality and degraded examples of most communities. It also encompasses a range of management histories with both historic (HOME) and recent (EFMO, HOME, PIPE, WICR) restoration work. In addition, the parks chosen are all small in size (mean 466 ha; range 79-831 ha), near the average for all parks in the Great Plains. The issues identified in their resource management plans reflect common concerns faced by small parks.

II. Recognized Management Need

Most Great Plains parks are small historic areas where prairie has only recently been treated as a principal resource. These prairie parks are too small to contain self-regulating populations of large mammals or to support natural disturbance regimes. For example, Stubbendieck and Willson (1987) found grazing by native herbivores (bison and elk) occurred on only three of 32 parks surveyed in the Great Plains. The

[2] SCBL/AGFO is administrated by one superintendent and is considered one park in this proposal.

remaining plant and animal populations in the fragmented habitats of the prairie parks are not only reduced and subdivided, they are increasingly exposed to ecological stresses associated with increased edges (Wilcove et al. 1986). Plants and animals native to the prairie parks are more likely to be exposed to external threats such as pesticides used on adjacent agricultural land.

If prairie parks are too small to maintain biodiversity over the long term, one solution might be to increase their size. Unfortunately, it is highly unlikely that the land areas of each of these parks can be increased enough to support viable populations of all native species along with local disturbance regimes of an appropriate scale. Most NPS units are surrounded by agricultural land, either cropland or rangeland (Stubbendieck and Willson 1987) (Table 2). Much of this land is enormously valuable for other uses. Political and economic realities indicate that commodity production will prevail over preservation.

A second, and more realistic possibility, is to manage prairie parks actively to protect, and in some cases, restore portions of their biodiversity. NPS managers are beginning to support the concept of "ecosystem management" primarily in the large natural parks (Agee and Johnson 1988). This concept promotes the development of resource management plans and actions designed to facilitate or augment natural ecological processes and minimize artificial edge effects. Species are being lost from the prairie parks due to their small size and insularity (Becker 1986). If trends are to be reversed, management actions such as species reintroduction, habitat restoration, population enhancement, control of pest species, and restriction of visitors will have to be implemented.

The issues of effective ecosystem management and external park threats are bound to the larger goal of conserving biodiversity at all levels of organization. The question that small parks in particular must address is to what extent can the species, communities, and processes under their stewardship be sustained. Given the land use context surrounding these parks, and the current or potential condition of the resources within their bounds, what level of sustainability is feasible? For the smaller units, perhaps a modest assemblage of prairie grasses and wildflowers is all that can be expected to persist. Larger sites might support a greater diversity of prairie plants, as well as small herbivores. Can the largest of the small parks also support a diversity of prairie, savanna, and woodland communities, some predator populations, larger herbivores, and at least some of the disturbance processes that maintain species and communities? Monitoring elements of biodiversity at the population, species, and community levels has both inherent value, and will contribute to our understanding of the sustainability of the natural resources of small parks.

We believe the future of biological diversity in the small prairie parks, and other small parks servicewide, requires active management of natural resources. The effective use of prescribed fire to manage woody plant invasion in the tallgrass prairie parks (Stubbendieck and Willson 1987) supports our prediction. The likely shift from laissez-faire to active management is the rational for the monitoring objectives and design presented in this proposal.

However, not all of the threats facing small parks can be solved through active resource management. Many problems begin beyond park boundaries and can only be addressed through interagency cooperation, negotiation with private landowners, public opinion, and legal avenues. Within the prairie cluster, pollution of water resources is the most urgent external threat. The springs, creeks and ground water of these small parks are particularly vulnerable to external pollution sources and cannot be insulated by buffer zones or within-park resource management. In order to pursue protection of these water resources, as well as terrestrial resources, managers must have access to high-quality, long-term data sets and rigorous analysis and interpretation of monitoring results.

Table 2. Land use within one mile of the unit boundary for NPS units in the Great Plains.

Unit	Land Use Types					
	Preserve	Rangeland	Crops Land	Forest	Residential	Industrial
MWR*						
AGFO		X				
CHRO		X	X			
EFMO			X	X	X	
FOLS			X			
FOSC					X	X
GWCA		X	X			
HEHO			X		X	X
HOME			X		X	
ICAG		X	X	X		
INDU			X	X	X	X
PIPE	X	X	X		X	X
SCBL		X	X		X	X
SACN		X	X	X	X	X
WICR		X	X		X	
RMR						
BADL		X	X			
BEOL		X	X			
BICA		X	X			
CUST		X	X			
DETO		X				
FOLA		X	X			
FOUS		X	X		X	
KNRI		X	X		X	
THRO	X	X	X			X
WICA	X	X	X	X		

TABLE 2 Continued.

SWR						
ALFL	X	X				
CAMO		X				
CHIC		X	X		X	X
FOUN		X				
LAMR	X	X				
LYJO		X	X		X	X
PERI		X		X		
PECO		X	X			

* See Figure 1 for an explanation of unit and region codes.

A monitoring program that places primary emphasis on the results of active resource management, and the assessment of external water quality threats is fully supported by park resources management plans (RMPs) (Table 3). The completion of baseline inventories and the development of monitoring protocols for listed species, indicator species, and other species of special concern are needs also clearly stated in RMP project statements. RMP project statements which explicitly or implicitly support monitoring are compiled as Appendix B.

III. Status of Inventories Done/Program Readiness

An important step in planning a long-term ecological monitoring program is a thorough scientific inventory of the biological resources and ecological processes on site. While small parks may be easier to inventory than large parks because they encompass less area, the completeness and quality of their inventories is often poor. This is generally true because small parks support small resource management staffs that do not include a range of specialists, and because small parks do not attract as much attention from outside researchers as do larger, well-known parks. Solutions to this dilemma will come, not from borrowing inventory programs developed for large parks, but rather by tailoring the inventory methods and objectives to meet the needs and limitations of small parks.

Prior to initiating on-the-ground surveys, managers should gather existing imagery, aerial photography, and thematic maps. A 1991 status report on MWR inventories indicated that imagery data was more complete for small parks (<1,215 hectares) than for large parks (NPS 1991). On average, the cluster parks had complete sets of aerial photographs for three points in time. Thematic maps, including soils and vegetation, were generally available for the parks that use geographic information systems (EFMO, HOME, SCBL/AGFO, WICR).

After compiling initial thematic and imagery data, managers should conduct or contract for preliminary site inventories, examining species, communities, and evidence of ecological processes. The five cluster parks have completed significant natural resource inventories. Table 4 shows the

Table 3. Inventory and monitoring project statements in resource management plans.

Codes	Restoration Methods	Prairie/Savanna Management	Biological Diversity	Pest/Exotic Management	Water Quality	Air Quality	Visitor Use
AGFO		Monitor Grasslands	Inventory Fauna & Monitor: 1)Listed Species 2)Indicators of Habitat Quality	Monitor Species of Management Concern	Monitor Water Quality: 1)Chemistry 2)Benthic Macroinvertebrates 3)Hydrology		
EFMO	Monitor Restoration Success	Inventory Forest Baseline	Inventory Baseline Fauna	Monitor Purple Loosestrife Control	Inventory & Monitor Wetlands		
HOME	Monitor Prairie Restoration	Monitor Prairie Management	Inventory Baseline Wildlife (birds, amphibians, reptiles & insects) Monitor Beaver Population	Monitor Smooth Brome & Woody Plant Control	Monitor Water Quality: 1)Nitrate Levels 2)Cub Creek Benthic Macroinvertebrates 3)Ground Water Pollutant Levels 4)Hydrology	Monitor Air Quality	Monitor Visual Quality of Prairie Monitor Visitation Patterns

Table 3 cont. Inventory and monitoring project statements in resource management plans.

Codes	Restoration Methods	Prairie/Savanna Management	Biological Diversity	Pest/Exotic Management	Water Quality	Air Quality	Visitor Use
PIPE	Monitor Succession Rates & Restoration Needs of Old Fields	Monitor Fuel Loads	Inventory (large mammals, amphibians, reptiles, insects, mollusks, mosses liverworts, fungi) Map/Monitor Rare & Endanagered	Monitor Sumac Control Monitor Exotic Species Control	Monitor Water Quality: 1)Contaminants 2)Benthic Macroinvertebrates Monitor Wetlands		
SCBL		Monitor Fire Effects on 1)Fuel loads 2)Select Species	Monitor Species on Edge of Range Inventory Birds, Fish & Butterflies Populations	Monitor Prairie Dog Control		Monitor Lichens	Monitor ORV Impacts
WICR	Monitor Landscape Restoration		Inventory/Monitor Baseline Resources		Monitor Water 1)Benthic Macroinvertebrates 2)Chemistry		

Table 4. Comprehensive biological inventories in prairie cluster parks.

Park	Biological Component						
	Vascular Plant	Lichen	Mammal	Bird	Fish	Reptile/ Amphibian	Insect
EFMO	Blewett 1986	--	--	--	--	--	Longhus 1991
HOME	Stutton, et al. 1984	--	--	--	--	--	--
PIPE	Becker 1986	Willson and Vinyard 1986	Snyder and Best 1988	Snyder and Best 1988	Schmidt 1989	--	Glen-Lewin 1991
SCBL/ AGFO	Weedon 1986	--	Cox and Franklin 1989	Cox and Franklin 1989	Stasiak 1990	Cox and Franklin 1989	--
WICR	Hassen 1987	--	Donegon et al. 1983	--	Foster 1989	--	Hargrove 1983

most recent comprehensive survey by resource component for each of the five parks. Appendix C provides a complete list of scientific studies and surveys conducted in the parks.

Comprehensive vascular plant surveys were done in all five parks during the 1980s. In addition, most park surveys included quantitative measurements of prairie community structure. Stubbendieck et al. (1992) produced digital maps of exotic plant species distributions at PIPE and WICR, and is currently working on exotic plant species maps for EFMO and SCBL/AGFO. Estimates of floristic completeness were compiled by Bennett (1992) (Table 5).

Unfortunately, baseline conditions are not as well established for all resource categories. Inventories of mammals, reptiles, amphibians, and insects are the least complete (Table 5). Furthermore, very little is known about the ecological processes still functioning in these small parks. An exception is productivity (biomass) estimates associated with the fire ecology study at SCBL/AGFO (Dodd 1993). The priorities for completing inventories reflect the emphasis of this monitoring program on active resource management and assessment of external threats as developed later in this proposal. High priority inventory needs are presented in Table 6.

Although none of the cluster parks are currently pursuing a comprehensive monitoring program, a number of monitoring protocols are developed and ready for testing (Table 7). For the most part these protocols address information needs associated with active management of park resources or track potential biological changes associated with external park influences. How these existing protocols fit into the overall monitoring design is described in the Monitoring Program section.

IV. Monitoring Program Design

Monitoring Strategy

Long-term success of this monitoring program will depend upon four key strategies.

Limited Scope. In order to sustain a monitoring program within the context of small parks, monitoring must be limited in extent, precise in focus, and targeted toward significant issues and resources. This program will focus on three high priority resource issues: (1) ecosystem restoration and management, (2) external threats, and (3) biological diversity.

Ecological Framework. The themes developed in this monitoring proposal revolve around an ecological question that small parks must address: To what extent are the species, communities, and ecological processes under their stewardship sustainable? This question is central to management decisions, and is also relevant to the emerging disciplines of restoration ecology and conservation biology. While this program does not attempt to monitor everything, the focal issues will be addressed at landscape, community, and population levels to provide comprehensive, and ecologically sound, management feedback.

Standards. Ecologically measurable endpoints, or standards, will be developed for each monitoring element in order to: 1) identify and assess impact-induced changes before large scale damage has occurred and 2) evaluate and adjust management responses. Monitoring results will be accessible and fully integrated into the RMP planning process.

Table 5. Status of biological inventories in prairie cluster parks *

	Flora		Fauna						
			Percent Complete						
Park Code	Percent Complete	# of Plant Species	Fish	Birds	Amphibians	Reptiles	Mammals	# of Faunal Species
AGFO	90	241	> 80	100	> 80	> 80	100	131
EFMO	90	467	unknown	< 50	unknown	< 50	< 50	63
HOME	95	240	< 50	100	< 50	< 50	< 50	166
PIPE	98	568	> 80	> 80	unknown	unknown	> 80	167
SCBL	85	287	unknown	100	> 80	> 80	100	138
WICR	60 **	462	50 - 80	> 80	< 50	< 50	< 50	175

* from Sullivan (1991) and Bennett (1992)

** 90 additional species have been added to WICR flora since this 1991 report was compiled

Table 6. Priority inventory completion needs.

Ecosystem Restoration & Management	External Threats	Biological Diversity
1. Complete imagery, hydrology, soils, topography & substrate maps in digital form to guide appropriate model selection for restoration standards.	1. Complete baseline thematic maps of watershed & landuse, groundwater tables & pollution sources.	1. Complete inventories for mammals, birds, reptiles & amphibians.
2. Complete baseline inventory for model vegetative communities.	2. Complete lichen inventories for air quality baseline.	

Table 7. Existing prairie park monitoring protocols.

Protocol	Origin
Aquatic Resources	Multi-park
Pest Species (Prairie dogs)	SCBL
Fire Effects	SCBL/AGFO
Restoration	EFMO;HOME;WICR
Exotic Plants	PIPE; WICR
Rare Species (Plants)	PIPE;WICR

Partnerships. To successfully initiate long-term monitoring in small parks, inherent problems of understaffing, high turnover, and poor institutional memory must be recognized and addressed. Partnerships with local colleges, universities, and other agencies will be emphasized to bridge these gaps and maintain continuity and quality control.

With this strategy in mind, we propose to adopt a modification of the conceptual monitoring plan or framework proposed by Spellerberg (1991) (Figure 2). This model emphasizes good planning, including the development of specific monitoring objectives, logistical support to continue the monitoring program over time, and coordination with other related programs. It is particularly relevant to the I&M pilot park concept in that it proposes preliminary or pilot monitoring projects be developed and tested before full or widespread application.

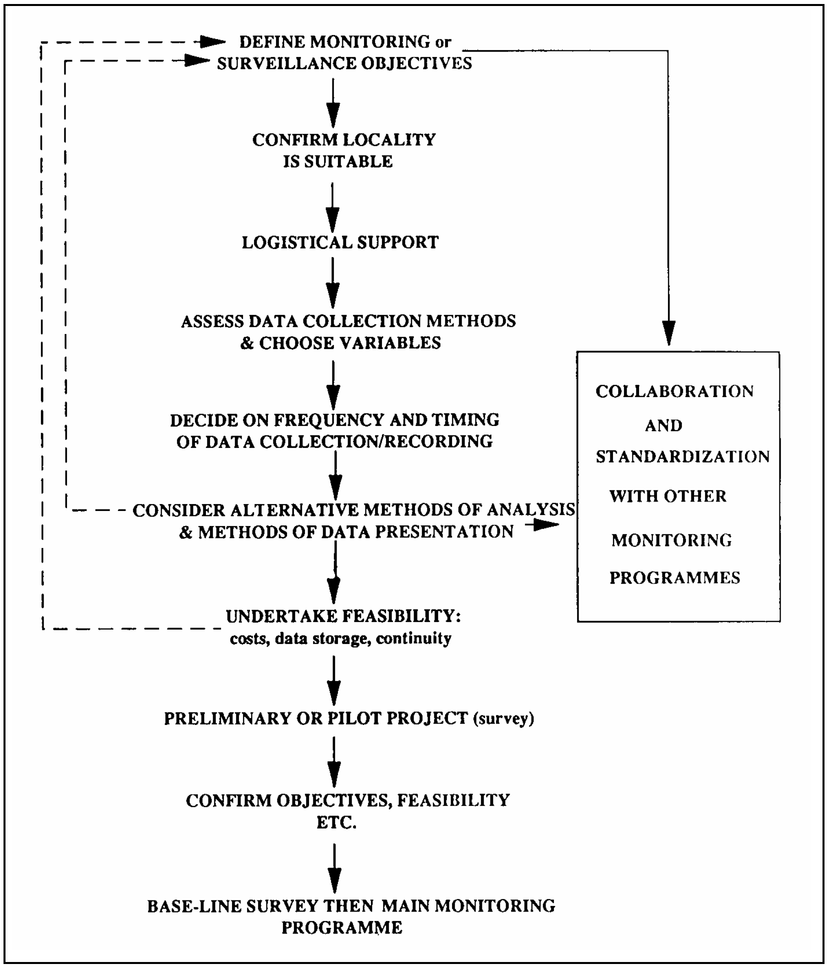

FIGURE 2. Prairie conceptual monitoring plan.

<u>Monitoring Objectives and Resource Focus</u>

The overall goal for this prairie cluster I&M proposal is to develop and/or implement monitoring protocols for resources likely to be enhanced or alternately suppressed by active management and/or external park threats.

Program objectives to reach this goal include:

1. Complete high priority inventories.
2. Test existing protocols for cluster-wide applicability.
3. Develop and test additional protocols for high-priority resource issues.
4. Design mechanisms to integrate monitoring results into park decision-making.
5. Achieve program accountability through periodic evaluation.

The three priority resource issues are discussed in detail below.

To what extent are small remnant and restored prairie ecosystems sustainable?

Ecosystem Restoration and Management

The parks included in this cluster, as well as many other Great Plains parks (Table 1), contain high quality prairie remnants, sites requiring complete restoration, and a continuum of resource conditions in between these two extremes. Restoration of missing components, and management to simulate missing processes are tightly linked and both essential to community persistence.

The roots of restoration ecology can be traced to Aldo Leopold and the conservation ethic that he espoused (Jordan et al. 1987). In 1935 when a small Civilian Conservation Corps crew under Leopold's direction began restoring prairie at the University of Wisconsin Arboretum, it was the only CCC project on a university campus, and it was administered by the National Park Service (Sperry 1989). In 1939, soon after the Curtis Prairie was begun, HOME began restoring prairie using sod transplants and seed collected from nearby prairies. In the 1960s and 1970s, old farmland was seeded to prairie grass at WICR and SCBL. While much of this early work appears to be moderately successful, the restoration methods were, in most cases poorly documented, and the process of establishment of the prairie species was not monitored. Consequently, NPS has learned little about how to successfully restore prairie ecosystems over the last fifty years, and has not been a substantial contributor to the development of restoration theory or methodology.

In a 1988 summary of resource management issues, MWR parks identified restoration as the greatest unmet funding need (NPS 1988)(also see Appendix B). In response to that need, renewed restoration efforts have begun with short-term funding from the Natural Resource Preservation Program (NRPP). The current emphasis is on setting clear objectives, tying those objectives to natural community models, and following up restoration work with monitoring in order to gauge success. In 1991, WICR completed an action plan that set a long-range goal to restore 1000 acres of the park to prairie/savanna communities. In 1993, Homestead completed an action plan that outlines 10 years of restoration work. PIPE, SCBL, and EFMO have also made substantial progress towards the completion of restoration action plans.

Long-term monitoring is essential to successful ecosystem restoration and management for several reasons. First, monitoring provides a means to evaluate whether the performance objectives of the project have been met. Secondly, monitoring provides feedback that can be used to alter or plan future management actions. As in natural systems, climate, biotic interactions, and disturbance events cause ecosystem restoration and management to be a dynamic process, rather than a static course of events. Feedback from monitoring should allow managers to respond appropriately to changing resource condition and management needs. From a broader perspective, monitoring allows NPS to contribute to the young science of restoration ecology. Not every restoration is successful. By including a monitoring component, even failures can contribute to an understanding of how communities function (Ewel 1987; Hiebert 1990).

Bradshaw (1987) describes ecosystem restoration as both a series of technical problems, and as a fundamental test of our understanding of ecosystems. Ecological knowledge, such as the factors limiting plant growth, or natural successional processes, contributes to getting the technical aspects of restoration right (Bradshaw 1987). Restoration also offers ecology a chance to learn by "synthesizing communities rather than reducing or analyzing them" (Diamond 1987). Funding and time constraints motivate restorationists to look for the minimal components and functions that must be restored in order to produce sustainable communities (Diamond 1987). These issues are also relevant to ecologists searching for the fundamental ecological processes that mold natural communities and ecosystems.

Monitoring restoration and management will answer the practical questions of whether specific management methods are working. In the larger context, it will be aimed at assessing whether and to what extent small remnant and restored prairie communities are sustainable. Most restoration work is focused on two basic issues; 1) introducing or increasing populations of appropriate species at desirable proportions, and 2) eliminating exotic species or native woody invaders (and 3) restoring natural processes that aid a remnant in becoming self-sustaining (Kline 1987). In order to gauge reintroduction success, both initial establishment, and long-term persistence should be monitored. Such an approach is currently being employed at WICR. Exotic species monitoring is discussed under the External Threats heading.

Prairie and savanna management is primarily aimed at reintroducing, or at least imitating, the landscape level forces of grazing and fire that historically influenced the dynamics of these communities. Although most Great Plains parks are too small to support large herbivores, prescribed fire and mowing are commonly used to manage both restored and remnant prairies. All of the parks participating in this cluster use prescribed fire to manage vegetation.

Fire has dramatic short- and long-term effects on plant community structure in grasslands (Abrams and Hulbert 1987). In particular, fire may alter species richness, diversity, competitive interactions and patch structure. Prairie vegetation is dominated by a few matrix-forming species, such as big bluestem. These species occupy the majority of space in the community. Minor species occur in the spaces between the larger dominants. Different disturbances have a differential effect on the matrix species, which affects minor species. Fire may increase the dominance and competitive ability of some matrix species and remove many minor species. However, fire may also reverse the decline in diversity in tallgrass prairie attributed to the development of a thick layer of litter and standing dead material, which may inhibit germination and growth of many species (Knapp and Seastedt 1986). The diversity and production of prairie and savanna vegetation will be the primary means of measuring the effectiveness of fire as a management tool.

Another measure of restoration and management success is the ability of a remnant or restored prairie to support a diverse array of animals. Currently faunal inventories are not complete for the cluster parks, nor have many monitoring protocols been developed. Once baseline inventories are complete, individual species or groups of species will be selected to monitor the overall health of these communities. Butterflies may provide a particularly good indicator assemblage because they include both generalist and endemic prairie species (Sedman and Hess 1985), interact with prairie vegetation as both herbivores and pollinators, and occur at a scale appropriate to small parks. Obligate prairie birds are known to occur at a number of the cluster parks (bobolinks at PIPE, burrowing owls at SCBL). The nesting success of these species will also be a future monitoring focus.

What are the landuse and watershed impacts to small prairie preserves?

External Threats
A total of 55% of the threats to national parks are estimated to be of external origin (USDI 1980) (Figure 3). The Natural Resources Assessment and Action Program (NPS 1988) identified the impacts of external watershed and urban development on park ecosystems as two major issues facing NPS.

Agricultural, residential and industrial development are prominent land uses around most of the cluster parks (Table 2). PIPE is the only cluster park bordered by a natural area preserve. Because a primary focus of these parks is interpreting historical scenes, preserving undeveloped viewshed is an important issue. The small size of these parks makes them particularly susceptible to outside visual intrusions. GIS models, such as those currently being applied at WICR, will be used to simulate potential viewshed changes under different development predictions.

Prairie streams that exist today are ecologically interesting because their biological communities integrate the effects of landuse, water quality and environmental change. Although prairie streams were historically turbid, turbidity has increased as a result of agricultural runoff. Increased turbidity and pesticide and nutrient loading have decreased biodiversity in many prairie streams. Prairie streams near urban centers face additional water quality threats from sewage and industrial pollution. Prairie parks are small and cannot control watershed changes. However, monitoring stream biotic and physical variables can effect management action through legal standards established by the Environmental Protection Agency (EPA) and state water quality enforcement agencies. EPA and state permitting agency records will form the basis for monitoring external watershed threats. Benthic macroinvertebrate diversity and water chemistry will be used to monitor overall stream health.

Of all external threats to national park resources, none are probably so insidious as those associated with air pollution (Stottlemeyer 1987). Current NPS research on the biological and ecological effects of atmospheric contaminates is limited to three areas: impacts on plants from ozone and sulfur dioxide, biomonitoring, and ecosystem response to acidity. The focus of biomonitoring has been on detection of elevated levels of heavy and trace metals in plant foliage and on detection of foliar damage in plant species sensitive to ozone. Possibly the worst air pollution effects in the national parks are the results of elevated levels of ozone (Bennett 1985). A NPS survey of foliar damage to common milkweed indicated that ozone is present in at least 20 parks, including HOME and PIPE, at concentrations above the foliar injury threshold for these species. The effect of elevated levels of sulfur oxides, a common pollutant especially in the East and Midwest, on sensitive lichen species also is under study at a number of parks receiving differing levels of exposure (Wetmore 1985).
The lichen floras of small prairie parks will be inventoried and, where appropriate, monitored for heavy metals. Monitoring biological effects of ozone will continue in select parks.

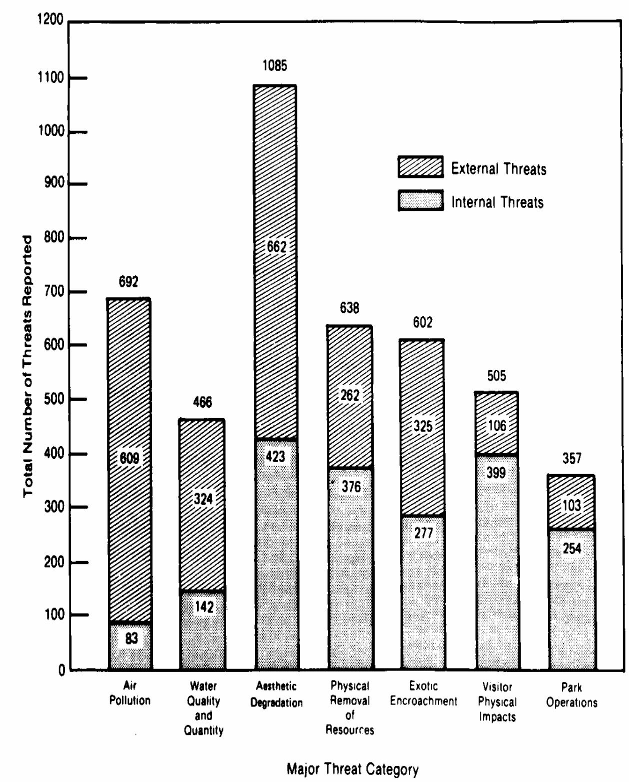

FIGURE 3. National Park threats.

Exotic or introduced species are those which have been brought from other regions through human activities, directly or indirectly, into park areas from the time of settlement to the present (Lewin 1987). The invasion and persistence of exotic species is a major problem in national parks. From a park manager's perspective, exotic species are considered undesirable because they 1) give park visitors a false impression of the native biota, 2) may not be representative of the park's appropriate natural or historic scene, 3) may inhibit the return of native species to disturbed areas, and 4) may interfere with successional processes. Exotic species can influence ecological processes including trophic relationships, interspecific competition, primary and secondary succession, nutrient cycling, system productivity, diversity, and stability (Bratton 1982). Because small parks are often inadequately buffered against edge effects, they are highly prone to exotic encroachment. Exotic species monitoring will build upon the distribution maps and exotic ranking system that have been employed at WICR and PIPE (Stubbendieck

What are the impacts of fragmentation on park resources?

Biological Diversity

et al. 1992), and are currently in preparation at SCBL and EFMO. In addition to distribution and abundance data, external exotic sources, control methods, and the effectiveness of buffer zones will be evaluated through monitoring.

Small parks probably contain most of the National Park System's biotic diversity (Quinn and Harrison 1988; Stohlgren and Quinn 1992). Furthermore, some factors influencing extinction rates, such as habitat fragmentation and exotic species introductions (Reid and Miller 1989), may have a more pronounced effect in small parks where edge effects are magnified and buffer zones are narrow.
Biological diversity may be defined as "the variety and variability among living organisms and the ecological complexes in which they occur" (Noss 1990). Increasingly, the conservation of biodiversity is being recognized as an issue of biological impoverishment at multiple levels of organization, rather than simply the loss of species (Noss 1990). In order to track the full range of biodiversity, several levels of organization (i.e. landscape, community and species) should be monitored.

The spatial scale of landscapes is on the order of tens to hundreds of sq km (Risser 1984), while the parks included in this cluster range from approximately 1 to 11 sq km in size. Because these parks do not encompass the landscape in which they occur, they are particularly vulnerable to outside land-use and watershed threats. Even for larger national parks, legal boundaries rarely coincide with the biotic boundaries necessary to maintain ecological processes (Newmark 1987).

As the land surrounding a park is modified for human use, landscape level impacts include changes in landscape heterogeneity, patch size, patch density, and linkages between similar patches (Forman and Godron 1986; Noss 1990). At this organizational level, macro-scale variables may be an efficient way to monitor biological health (Keddy 1991). Aerial photography, county land-use records, and GIS will be used to monitor land use. Monitoring will identify sensitive natural areas, locate development activity that is likely to impact on the parks, and establish trends in land use. Such information would be useful in identifying activities that threaten park resources and in determining compliance with federal land use legislation. Within-park changes in the size, frequency of occurrence, and distribution of community types will also be monitored through aerial photography and vegetation maps. Because landscape level processes such as disturbance cycles and energy flow occur above the organizational level of the community (Noss 1990), attention will be focused on ecotones and the juxtaposition of community types.

Ecologists often focus monitoring studies on vegetative communities because plants are relatively permanent in comparison to animals, and because vegetation reflects underlying edaphic factors and local climate, as well as past and present management (Goldsmith 1991). Community-level monitoring will focus on the identity, frequency, and abundance of the species belonging to a representative sample of the significant vegetative communities in each park. Measures of within and between habitat diversity (Magurran 1988) will be employed, as well as some measure of environmental integrity, such as the "coefficients of conservatism" (Wilhelm and Ladd 1988) that are currently employed by The Nature Conservancy (TNC) (Ladd personal communication).
Carefully selected individual species or guilds of species may serve as valuable indicators of the state of health of particular habitats or environments (Keddy 1991). In parks that are too small to support large vertebrate populations, insect and other arthropod species may provide a good measure of within-park ecosystem health. While many butterfly species are generalists, others are endemic to prairies, and feed exclusively on certain species of prairie forbs (Sedman and Hess 1985; Selser and Schramm 1990). This host specificity may make prairie butterflies good ecological indicators of the health of prairie communities (Tdkulsky 1985). Monitoring certain species may also provide a measure of restoration success. For example, monitoring the diversity of insect pollinators may be useful in evaluating the long-term likelihood of restoration success for plant species dependent on specific pollinators. Indicator species may also prove important in examining transitions between community types. Prairie and woodland plant associations have distinct spider faunas, while savanna spider faunas are weakly similar to both (Wolff 1990). An array of insect and arthropod species such as those proposed under EPA's

Environmental Monitoring and Assessment Program (Hunsaker and Carpenter, 1990) will be examined for utility and widespread applicability as environmental indicator species.

For small parks with limited resources, population level monitoring of biodiversity will usually be directed towards rare species. Monitoring programs at the population level must be designed to fit the life history, habitat requirements, and distribution of individual species (Pickart 1991). The intensity of population monitoring will depend upon the degree of rarity and the severity of threats to species persistence. For endangered species, where there is a legal mandate for protection, a rigorous and comprehensive monitoring strategy that includes demographic and environmental components is required. Demographic monitoring should includes both structural (age classes, sex ratio, dispersion and range) and functional (recruitment, mortality, reproduction, metapopulation dynamics) components (Noss 1990). Environmental monitoring might includes biotic interactions, habitat variation, and physical limiting factors. For small isolated populations, or populations known to have low genetic diversity, genetic monitoring may also be necessary (NPS-1992). Examples of genetic components include allelic diversity, effective population size, and gene flow.

The cluster parks support two federally endangered plants, and a number of state-listed species. The MWRO and WICR have supported research and monitoring of Missouri Bladderpod (Lesquerella filiformis) since the mid 1980's. More recently, Western Prairie Fringed Orchid (Habernaria lacera) was discovered at PIPE. Initial endangered species monitoring will aim at evaluating and expanding upon protocols developed for Missouri Bladderpod. Once these protocols are in place, emphasis will be placed on developing a program for the Prairie Fringed Orchid. While the details of each monitoring protocol must be tailored to fit the life history and habitat utilization of the target species, we hope to develop an iterative monitoring process that will be applicable to other rare species.

Monitoring Program

We selected individual monitoring components after critical evaluation of the priority natural resource issues discussed above and a review of the status of park resource inventories (Table 5) and previously developed monitoring protocols (Table 7). Table 8 presents these components with priorities in bold. Phase I of this cluster proposal will implement multi-park water quality monitoring protocols developed by the NPS Water Resources Division (WRD). Also under Phase I, those protocols that were previously devised for use at a single park (i.e. T&E population trends) will be tested at other cluster parks and modified, if necessary, for wider application. Phase I monitoring components are described below.

Table 8. Monitoring Components (top priorities in bold).

Scale	Ecosystem Restoration & Management		External Threats		Biological Diversity
	Restoration Methods	Prairie/Savanna Management	Pest/Exotic Management	Water/Air Quality	
Landscape		**shifting of community boundaries & width of ecotones in response to prescribed fire**	external sources, dispersal corridors & buffer zones	**pollution sources**	ecotones, linkage of community patches & dispersion corridors
Community	**progress toward model community composition, structure & diversity**	**effectiveness of prescribed fire for maintaining prairie/savanna composition & structure**		**water chemistry and macroinvertebrate diversity as indicators of stream health**	faunal inventories to choose indicator species visitor use facilities & development impacts
Species/Guild	**establishment success of planted species**		**locations, distribution & abundance of problem species**	lichen abundance & diversity as indicator of air quality milkweed as a biomonitor of ozone pollution	genetic diversity of indicator species to assess effects of insularity
Population		insects/spiders as indicators of community health	**effectiveness of exotic control methods**	toxicity monitoring of daphnids & minnows	**location & population size of rare plants** **demographic, & genetic monitoring of rare plants**

Restoration Methods

Progress toward Model Community Composition, Structure and Diversity. One goal of recent restoration efforts throughout the cluster parks is to use high-quality remnant prairies and savannas as models for restoration. The composition and structure of restored communities will be compared to model communities at several stages in the restoration process, in order to evaluate restoration success and plan additional work. While traditional community sampling and analyses will form the basis for this monitoring program, additional parameters that address the restoration goals and are sensitive to the restoration process will be sought. Protocol development will build upon community monitoring accomplished at WICR over the last 3 years as part of a landscape restoration project.

Establishment Success of Planted Species. The purchase of native seed and transplants remains one of the most expensive components of restoration projects. For many species, little is known regarding the best plant material, planting methods, or timing for successful introduction. Monitoring initial establishment and persistence through time for species introduced within a restoration will help answer these questions. Monitoring protocols developed at WICR over the last three years will be tested throughout the cluster parks.

Prairie/Savanna Management

Shifting Community Boundaries and Width of Ecotones in Response to Prescribed Fire. Vegetation boundaries change over time in response to climate and large-scale disturbances such as fire. Fire is particularly effective in changing species distributions near the prairie-forest border. Changes in woody plant distribution in tallgrass and savanna parks will be monitored using historic and recent aerial photography. In select areas, density of woody stems and basal cover of herbaceous species will be measured along permanent transects.

Effectiveness of Prescribed Fire for Maintaining Prairie/Savanna Composition and Structure. Fire is a recognized component of the prairie disturbance regime. Generally fire increases the competitive ability of the dominant species, and may, if applied too frequently, decrease overall species diversity. Maximum species richness and diversity in prairie occurs in areas with periodic, but not annual burning, and some small-scale disturbance which provides germination sites for annuals. Production (biomass) and density of dominant species will be measured pre- and post-burn at SCBL using a protocol and computer program (VEGECALC) to be completed in late 1993. Species diversity will be measured in burn units and changes will be tracked over time using a measure of community similarity. Following testing at SCBL, the protocol and VEGECALC will be used in the other cluster parks' fire programs.

Exotic/Pest Species

Locations, Distribution and Abundance of Problem Species. Visual counts have been used to accurately estimate populations of black-tailed prairie dogs, a common pest species in several Great Plains parks. Procedures for visual scan monitoring of the prairie dog population at SCBL were developed and tested in 1987. Visual counts and live trapping of the population was used to develop and verify a site-specific linear regression model to estimate population size. Along with visual counts, mapping of the surface area encompassed by the prairie dog population is needed to determine density levels. Guidelines for mapping prairie dog colony surface area were also developed at SCBL. Visual scan monitoring and the regression model used to estimate population size will be further tested at SCBL. After additional refinement, these procedures will be applied to other small to medium sized parks with prairie dog management programs.

Effectiveness of Exotic Control Methods. Exotic species life history information will be compiled and analyzed to identify morphological growth stages susceptible to burning, cutting, or chemicals. Pre- and post treatment stem or tiller densities and reproductive output will be recorded and the effectiveness of the control agents evaluated.

Water/Air Quality

Land Use and Pollution Sources. All parks in the cluster have historic photography and recent, low-level aerial photographs of park and surrounding area resources. Photograph and satellite image processing using GIS will detect gross changes in adjacent landuse and identify suspected pollution sources. Ground surveys or public records will be used to verify pollution sources.

Water Chemistry and Macroinvertebrate Diversity as Indicators of Stream Health. Water quality monitoring was begun by the WRD in six small prairie parks (AGFO, HOME, PIPE, HEHO, GWCA, and WICR) in 1989 as part of a comprehensive analysis of the ecological status of each park's aquatic system. Permanent sampling sites were established along streams in each park for water chemistry and macroinvertebrate monitoring. Macroinvertebrate data were analyzed to obtain basic aquatic community data including taxa richness and density of macroinvertebrates. Sites and time periods were compared and pertinent life history information summarized. Water chemistry samples were collected before streams were disturbed by macroinvertebrate collecting. Following the initial survey the WRD recommended monitoring be continued and provided each park a methods manual. Biological and chemical monitoring will continue at AGFO, HOME, PIPE, and WICR as part of this proposal. Continued monitoring at HEHO and GWCA will be the responsibility of the parks and the MWR.

Monitoring of T&E Species

Location and Population Size of Rare Plants. Species locations and distribution will be mapped for all state and federal T&E species using GIS. Population size and age structure (if appropriate) will be monitored at a 1-3 year interval depending on individual life histories.

Demographic and Genetic Monitoring of Rare Species. A monitoring protocol in use at WICR since 1988 will be employed annually to track fluctuations in population size of the largest WICR population of Missouri Bladderpod. Methods used in a two year demographic study will be modified to monitor mortality at different life stages, and mortality and fruiting within a number of glade microhabitats. Other aspects of the population biology of Missouri Bladderpod that should be considered for additional monitoring include seedset, seedbank dynamics, genetic diversity, and metapopulation dynamics. In order to ground population-level monitoring within a community context, the monitoring program will also track changes within the glade community and relate those changes back to the distribution and population trends for the species. A baseline Missouri Bladderpod distribution map was produced for the Bloody Hill Glade in 1990. Since 1991, vegetative surveys of woody density, and herbaceous frequency and cover, have been completed for 4 of the 5 glades within the park that support Missouri Bladderpod. This data will form the community backdrop for Missouri Bladderpod monitoring.
Phase II of the monitoring proposal will involve the design and implementation of protocols for resource components scheduled to be inventoried. Elements which may be included in Phase II are listed below:

Insect/Spider Diversity
Lichen Diversity and Abundance
Adjacent Land Use
Bird Nesting Success
Visitor Use Impacts

Table 9 shows a schedule for the development and implementation of both Phase I and II monitoring elements.

V. Scientific Credibility and Capability

Capability

Small parks are faced with several problems that make long-term projects difficult to sustain. Resource management programs are often minimally staffed. Many small parks have a single resource management specialist with a wide range of duties. There is a high rate of turnover, and often there are gaps when a position is left vacant. In November 1991, the Midwest Region held a prairie restoration workshop to begin addressing these problems as they relate to long-term restoration projects. One common sentiment expressed at the workshop was the difficulty for a single resource manager to develop a detailed restoration plan. Another common problem was the lack of documentation concerning past restoration work. As a result of the workshop, it was determined that the region could assist parks by providing professional restoration advice, developing a more systematic and ecological approach to restoration planning, ensuring that ongoing restoration work is documented, and establishing a network of parks involved in restoration work.

In April 1992 a GS-9 restoration ecologist was hired under a 3-year term appointment to coordinate plan preparation, execution, and evaluation for regional restoration projects. The restoration ecologist is duty-stationed at WICR. Working with the restoration CPSU at the University of Wisconsin, and the Cooperative Park Studies Unit at the University of Missouri, the restoration ecologist provides a link between resource managers and restoration professionals.

In an effort to provide some continuity to the program, and to share information gained by resource managers with more extensive restoration experience, a network of parks has also been established. Currently resource management specialists at EFMO and SCBL, as well as the restoration ecologist, are assisting nearby parks with restoration planning and work. This tiered approach to restoration assistance has resulted in quicker response to restoration questions, more thorough restoration planning, and improved communication among a number of parks with similar restoration needs.

We propose using this same organizational structure to execute the initial phase of the monitoring program. The restoration ecologist will direct program activity until a program coordinator and additional staff can be hired. The base of operations for the program will remain at WICR. Currently office space and support facilities are adequate for the restoration ecologist and 2-3 technicians. A fully implemented program at WICR will require the construction of office space.

Table 9. Schedule for the development and implementation of monitoring protocols.

PHASE I

Resource	Protocol Developed	Year Implemented	Monitoring Frequency	Monitoring Level	Partners*
Model Community	1989	1994	1 Year	Community	LC
Establishment Success	1989	1994	2 Years	Species	LC
Fire Effects Composition/Structure; Ecotones	1993	1994	2 Years	Population/ Community	LC
Exotics Distribution; Control Methods	1993	1994	1 Year	Species	LC
Land use and Pollution Sources	1994	1994	1 Year	Landscape	--
Benthic Macroinvertebrates and Water Chemistry	1989	1993	Quarterly	Community	WR
T&E Population Trends	1989	1989	1 Year	Population	FWS
T&E Demographics	1989	1994	1 Year	Population	FWS

PHASE II

Insect/Spider Diversity	1995	1996	1 Year	Species/Pop.	LC
Lichen Diversity/Milkweed Damage	1995	1996	2 Year	Species	AQ
Adj. Land Use	1995	1995	5 Year	Landscape	--
Bird Nesting Success	1996	1996	1 Year	Species	LC
Visitor Use	1997	1997	1 Year	Species	--

*AQ=Air Quality Division
FWS=Fish and Wildlife Service

LC=Local College or University
WRD=Water Resources Division

We anticipate full implementation of the cluster proposal will require the following staff.

NPS Program Coordinator, Ecologist GS-11/12 (1.0 FTE)
Data Manager/GIS Support, GS-9/11 (1 FTE)
Administrative Assistant, GS-5/7 (.5 FTE)
Ecologist/Biometrician, GS-9/11 (1 FTE)
Aquatic Ecologist/Entomologist, GS-9/11 (1 FTE)
Botanist, GS-9 (1 FTE)
Seasonal Technicians, GS-7 (2.5 FTE)

<u>Credibility</u>

We will ensure scientific credibility of the proposed monitoring in two ways. First, we will continue and, where practicable, enhance working relationships (partnerships) within the NPS and with academic institutions and other government agencies. For example, WRD has inventoried the aquatic macroinvertebrates of prairie streams in six small parks in the MWR. Their final report outlines a program for monitoring the aquatic resources using biological criteria. In addition, they have tested monitoring protocols at AGFO. We propose that the WRD be a partner in implementing water quality monitoring in the cluster parks. Furthermore, the restoration ecologist has worked over the last three years to develop monitoring protocols for restoration work at WICR and other parks. A continuing partnership with the restoration CPSU at the University of Wisconsin ensures scientifically credible and statistically valid monitoring protocols are developed. Finally, the monitoring program will also make use of the data management and GIS knowledge developing at the University of Missouri for Ozark NSR and Buffalo NR under the Ozark Highlands Global Change Program.

Another way to ensure credibility is to develop a comprehensive decision support framework for the purpose of integrating monitoring results into managerial decision-making (NPS-1992). NPS-75 defines natural resource monitoring as "long-term systematic repetition of a specific resource survey and the analysis of those data to predict or detect natural and human induced changes in resource condition, and to determine if natural resource condition objectives are being achieved". In practice, monitoring often falls short of meeting this definition because the desirable or healthy state of the resource may be poorly understood or has not been described in terms of measurable ecological standards.

The environmental sciences have recently borrowed a paradigm developed to evaluate human health risks (NAS 1983) as a means of assessing toxicity effects and other chemical-related environmental problems. This paradigm may not be entirely appropriate to ecological risk assessment because it does not estimate indirect effects, effects at higher levels of organization such as community or ecosystem, or risk cascades (Lipton et al. 1993). However, several of its concepts may be useful to developing a framework for integrating monitoring feedback.

The concept of ecosystem health has recently been suggested for consideration in the NPS inventory and monitoring program. Operationally, the concept of ecosystem health should include determination of keystone species, critical communities, and important ecosystem-level processes, and should encompass both structural and functional attributes. Once a profile of the health of an ecosystem has been developed in terms of critical ecological characteristics, ecologically measurable endpoints should be formulated. An ecological endpoint is defined as an ecological parameter whose normal operating limits can be determined for the ecosystem in question. A major effort in ecosystem risk analysis is the identification of appropriate ecological endpoints that are indicators of ecological health and sensitive to early stages of anthropomorphic change.

While one goal of this monitoring program is early detection of resource degradation, a second goal is to evaluate the success of restoration and management methods. In this case, the profile of ecosystem health may be derived from one or more model communities, and the endpoints must be tied to the project objectives, and appropriate to the particular stage of restoration (Harrington 1990).

We propose incorporating standards based on measurable endpoints as an integral part of each monitoring protocol. Standards will specify both the magnitude of change that one is interested in detecting and the acceptable level of confidence. The establishment of monitoring standards provides a means for managers to integrate monitoring feedback into the decision support framework.

VI. Implementation Strategy and Budget

07/94 Note: The original proposal was written prior to a clear definition of the respective roles of the National Biological Survey and the National Park Service in implementing the Prototype Inventory and Monitoring program. This section of the proposal was rewritten to reflect those roles as they are currently defined, and to address review comments concerning the feasibility of implementing the original design. This revision also reflects the consensus view from the Omaha meeting that the success of this prototype depends upon a close partnership between the two agencies from the beginning of program design through a transition period to the NPS operational phase.

Implementation Strategy

The concomitant goals of deriving scientifically sound monitoring protocols, and ensuring their applicability to management issues will be accomplished through a three-phase implementation strategy.

In the initial **Design Phase**, the emphasis of the program will be on protocol development, with the NBS in the lead. The involvement of an NPS Coordinator and Data Manager during the design phase will be essential to tailoring the monitoring program to the resource management concerns of the prairie cluster parks, and to ensuring adequate communication between the cluster parks, NBS, and the associated research institutions. During the design phase, NBS will be responsible for funding.

The **Transition Phase** will occur as the researchers charged with protocol design are completing their initial analyses, and as the NPS is beginning to build the personnel and infrastructure to operate the program over the long term. Our discussions with the Shenandoah I&M staff made it clear that an adequate evaluation of monitoring protocols could not be accomplished until subject matter specialists were on staff. By hiring the NPS I&M program staff during a two-year transition phase, we hope to encourage evaluation and refinement of protocols through interaction between the researchers and the I&M staff. During the transition phase, both NBS and NPS funding will be required.

The final **Operational Phase** will occur when protocol development is complete, and the full I&M staff is in place. The NPS will be responsible for securing long-term program funding for the operational phase.

Budget

07/94 Note: Two elements of the revised budget are substantially different than that first proposed. First, an interagency review panel concluded that the budget proposed in the initial proposal was "too low to cover logistics". Our discussions with the Shenandoah staff confirmed that our original staffing estimates were unrealistic in order to maintain long-term consistency and high professional quality within the monitoring program. Based on these recommendations, the revised proposal includes a larger operational staff than that proposed in the first draft. The three staff specialists may be based at cluster parks to ensure adequate oversight of monitoring activities, and good communication with park managers.

Secondly, in order to incorporate a two-year transition period into program design, NBS support will be required for a longer period of time, and some NPS support will be needed at an earlier stage. This results in continuing NBS involvement through FY 1999, and a 200K increase in total NBS costs. NPS funding and FTE need to be secured for FY98, and will gradually increase over the two-year transition phase. Monitoring protocols cannot be adequately evaluated without first applying them over several years, analyzing the data, and assessing their pertinence to management decision-making. A transition period that focuses on cooperative review and refinement is critical to achieving the common goal of designing a monitoring program that is both scientifically sound and relevant to management.

Table 10 and a supplemental narrative description provide a cost analysis by program function for the first six years of the program. These costs include all NBS and NPS staff time dedicated to the monitoring program, infra-structure development, capitalized equipment, contract costs, equipment, supplies, and other program support. We developed these costs based on initial and projected staffing, the schedule for protocol design and implementation, and anticipated help from the parks and partners.

We believe the program costs outlined in Table 10 are reasonable and conservative. This proposal is cost effective because 1) it builds on a successful prairie park restoration organization and staff currently in place, 2) it will be based in a park with the largest restoration program of any of the prairie parks, and 3) it continues partnerships both between NPS and NBS, and with outside institutions.

VII. Servicewide or Multi-park Applicability

Multi-park applicability is a key design criteria for monitoring protocols developed under this cluster proposal. In addition, we have identified the 32 parks in the Great Plains (see Stubbendieck and Willson 1987) that will ultimately benefit from the protocols developed and tested. We have emphasized monitoring attributes likely to respond to management inputs and external factors common to small prairie parks. We envision most of the protocols developed would benefit other small parks servicewide and other small conservation areas such as natural landmarks and state conservation department and TNC sites.

Table 10. Projected 7-year expenditures by program function (in thousands).

	Phase 1: DEVELOPMENT			Phase 2: TRANSITION		Phase 3: OPERATIONAL
	FY95	FY96	FY97	FY98	FY99	FY00
PERSONNEL						
NPS Program Coordinator (GS 11/12)	35	52	54	56	58	**59**
Data Manager (GS 9)	20	35	38	44	46	**48**
Administrative Assistant (GS 5/7)	20			**25**	**27**	**29**
Specialist -- Ecologist/Biometrician (GS 9/11)				**38**	**42**	**44**
Specialist -- Aquatics/Entomologist (GS 9/11)				**38**	**42**	**44**
Specialist -- Botanist (GS 9)					**38**	**40**
Seasonal Biotechs (GS 5/7)				**24**	**36**	**36**
TOTALS	75	87	92	225	289	**300**
SUPPORT						
Travel	15	15	15	20	20	**20**
Office Space	45			**50**	**15**	
Computer Hardware/Software	40		5	**25**	25	**5**
Equipment/Supplies	8	5	5	7	10	**10**
TOTALS	108	20	25	102	70	**35**
PROGRAM						
Complete Inventories	50	40	20	20	4	
Test Existing Protocols	60	40	30	20	4	
Develop and Test New Protocols	65	75	100	100	100	
GIS Support	20	20	20	20	20	**15**
Contract Monitoring				**50**	**50**	**50**
TOTALS	195	175	170	210	178	**65**
PROGRAM TOTALS	378	282	287	537	537	**400**
National Biological Survey	378*	282	287	287	287	
National Park Service				**250**	**250**	**400**

Y94 and FY95 funding NPS funding indicated in bold

Table 10 (Supplement): Narrative Description of Personnel and Duties

NPS Program Coordinator (GS 11/12). Coordinates program with NBS. Works with NPS WASO I&M Coordinator to develop NPS staffing and infrastructure. Responsible for supervision and implementation of program in operational phase.

Data Manager (GS 9/11). Responsible for data management design, standards, and archiving. Provides computer hardware, software and network support.

Administrative Assistant (GS 5/7). Serves as administrative officer, prepares contracts, cooperative agreements, etc.

Ecologist/Biometrician (GS 9/11). Responsible for data analysis and summary, application of mathematical ecology to program goals, and statistical support.

Aquatics/Entomologist (GS 9/11). Responsible for implementation of water quality monitoring, including macroinvertebrate monitoring.

Botanist (GS 9). Oversees plant population and community monitoring. Ensures consistency in sampling methods, plant identification and synonymy.

Seasonal Biological Technicians (GS 5/7). Assist with monitoring.

VIII. Park Infrastructure and Organizational Structure

Each park in the prairie cluster has a full-time resource management specialist at either the GS-7 or 9 level. In addition, these parks have dedicated space and support facilities and equipment for resource management. Resource management staffs at EFMO, SCBL, and WICR have extensive experience in providing management assistance to smaller parks without onsite resource managers.

Six permanent NPS I&M positions are proposed (see Figure 4.). The program director and staff will develop and maintain strong ties to the parks, to scientists within the NBS, and to partners. Initially, we anticipate the program director will report to the MWR branch chief for resources management. Permanent I&M staff will be housed at WICR (see Scientific Credibility and Capability); most seasonals will be housed at the parks.

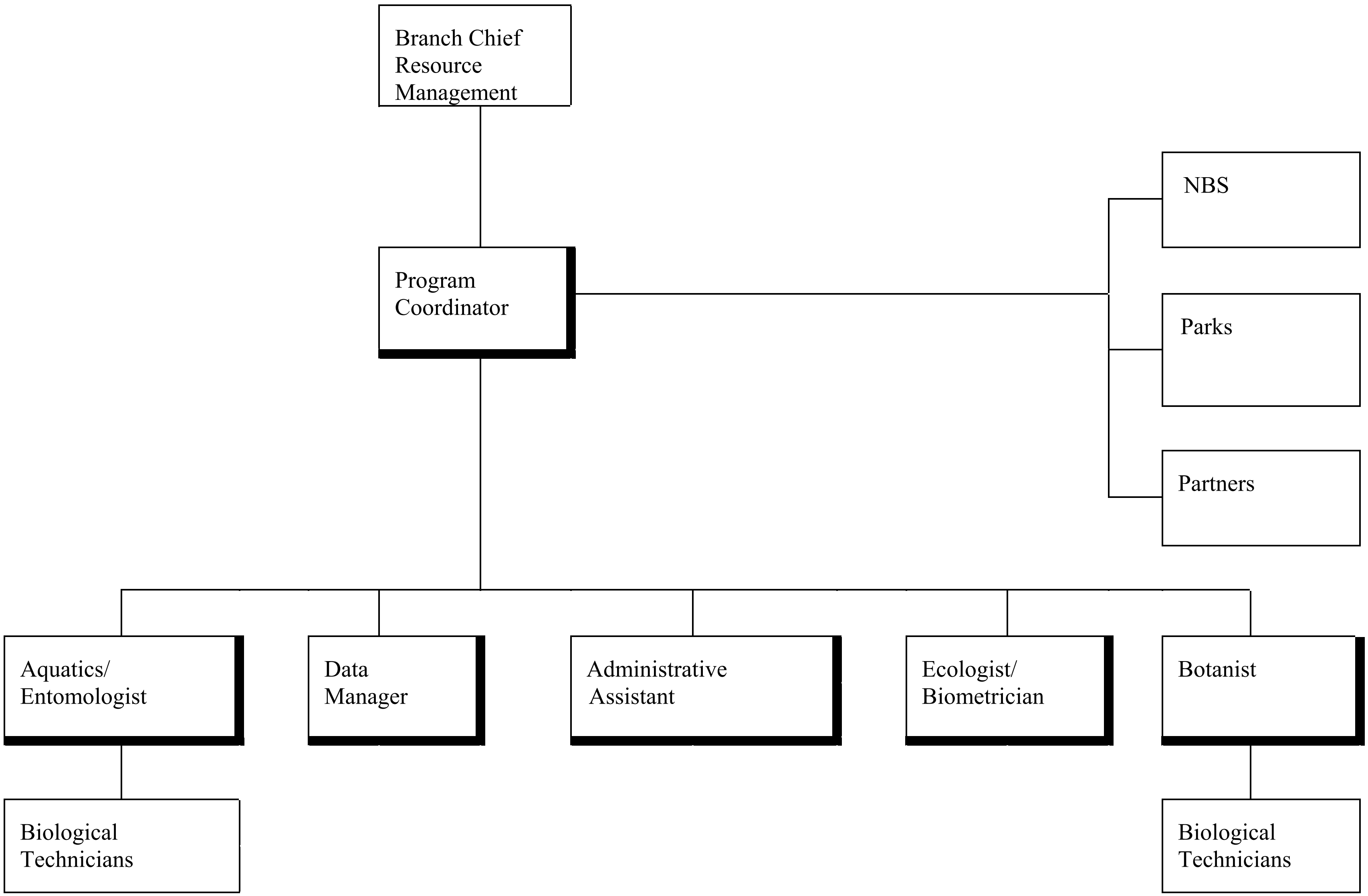

FIGURE 4. Proposed personnel organization.

IX. Data Management Plan

Monitoring will be undertaken for long periods of time, during which the people initially involved in establishing the program may change. Frequent changes in management and personnel in small parks are potential problems in maintaining long-term data sets. Therefore, we believe the initial success of data management under a prairie cluster proposal will require a full time data manager.

We also propose for the first two years of the prairie cluster I&M program that the NBS data management and GIS facilities at the University of Missouri provide data management support. The UMC facility already has experience with the application of long-term data sets as it serves the needs of the NBS Global Change Research Program for the Ozark Highlands. It has a dedicated data manager/GIS operator, a SPARC IPC workstation, and a Dell System 486 microcomputer with a 300 Mb hard drive. The facility supports GRASS and Arc/INFO and has access to expertise and graduate students within the University of Missouri Geographic Resources Center and Department of Geography. In addition, the biomatrician within the UMC School of Natural Resources provides consultation on study and monitoring design, sampling, and statistical analysis. Collaboration with the NBS/UMC will ensure data are stored and transferred accurately and data are secured from loss or damage.

During the initial phase of the monitoring program, standardized methods and procedures as well as accuracy tolerance limits will be established for measurements associated with each resource element that will be monitored. Standard operating procedures (SOP) for individual measurement techniques will be described. SOPs for the water quality monitoring protocol are outlined within "Manual for Implementation and Development of Aquatic Resource Inventory and Monitoring Methodology in Prairie Parks" (Boyle et al. 1990). This manual will serve as a prototype for other resource manuals to be developed.

A comprehensive database format and management system was developed by the WRD for the prairie parks water quality monitoring protocol. National Park Sample Collection (NAPSAC), is a dBASE III+ menu driven program that assists in data entry, storage, and classification of stream macroinvertebrate data. Output from the NAPSAC program is designed to interface with BSTRAP, a community analysis program that computes diversity indices and assesses similarities between communities. NAPSAC will facilitate the analysis of data and detection of change in prairie park streams. Similar customized software programs in dBASE III+ will be developed to store, analyze and produce reports for the other monitoring protocols proposed under program Phase I and II.

During this initial two-year period, a specific data management plan incorporating the various developed protocols will be designed. Documentation, backup procedures, access security, and file format standards, and other data needs will be developed to assure accessibility and transferability. In the interim, data entry and quality assurance for prairie monitoring databases will be the responsibility of the principal investigators. Normalization of existing data sets may be needed, and it will be the responsibility of the data manager to document linking of naming conventions or other tactics used during this process. We anticipate that the developing program within NPS for Internet accessibility will allow electronic information transfer between the program and investigators.

X. GIS System

The application of GIS for geographic and tabular data management in the prairie cluster monitoring program will serve several functions, including data storage, data archiving, and report facilitation (specifically change detection). In addition, the landscape scale at which GIS operates can allow regional analysis of threats to park resources.

Mapping, archiving, and analysis of geographically-referenced information will be supported at two levels: at the NBS GIS facilities at the University of Missouri-Columbia (UMC) and within individual parks with operational GIS. At the present time only WICR has an operational GIS, though spatial digital data is available for other prairie cluster parks. WICR runs a PC-based system using EPPL7 software, and is using the system to model how potential changes in adjacent landuse will affect the park's viewshed. HOME is also developing a system using EPPL 7. PIPE is developing a PC-based GIS and has 6 digital layers developed including soils, hydrology, topography and vegetation. SCBL is developing a PC-based GIS in collaboration with county government. Digital layers being developed under contract include soils and land cover. All four parks plan to use GIS to monitor and predict changes in exotic plant populations.

We propose that the NBS/UMC facilities/staff be substantially involved in the development and/or completion of nominal databases for the cluster parks. We estimate this work will take about two years to complete. Following the developmental phase each park would have a operational GIS using EPPL7 or comparable software. We anticipate the involvement of NBS/UMC staff will be minimal after two years. Future support for data management and analysis will be available at the NPS Tech Center at the University of Wisconsin--Madison.

XI. Linkage and Leveraging

Out of necessity the small prairie parks have developed close working relationships with nearby colleges and small universities. We believe these relationship can be strengthened under this proposal and that these institutions become full partners in the long-term monitoring program. Local colleges will be particularly useful as sources of labor for vegetative plots surveys and other intensive monitoring. We will pursue cooperative agreements to link each cluster park to a local college/university as follows:

EFMO	University of Wisconsin, Stephens Point
HOME	University of Nebraska, Lincoln
PIPE	South Dakota State University, Brookings
SCB/AGFO	Chadron State College, Chadron
WICR	Southwest Missouri State University, Springfield

The monitoring program will rely upon continued cooperation with the restoration CPSU at University of Wisconsin-Madison particularly regarding the development and testing of restoration protocols and standards. It will also make use of GIS support developing at the University of Missouri for Ozark NSR and Buffalo NR under the Ozark Highlands Global Change Program.

The Water Resources Division of NBS will be called upon for technical assistance with water quality monitoring. Efforts will also be made to share methods and results other federal, state and local water quality programs, such as the multi-agency Sny Magill Watershed Nonpoint Pollution Monitoring Project that includes EFMO.

The Nature Conservancy (TNC), with Kansas State University, has been involved in prairie research at the Konza Prairie (Manhattan, KS) for 30 years. More recently, they have begun an ambitious project to recreate a functioning tallgrass prairie ecosystem at the Tallgrass Prairie Preserve near Bartlesville, OK. We will pursue establishing a cooperative relationship with TNC, to learn from their past experience and to seek common solutions to shared monitoring needs.

The monitoring program will also establish links to the Oak Savanna Project, a multiagency effort spearheaded by EPA, TNC, and the University of Wisconsin, Stephens Point, to recover oak savanna ecosystems in the Midwest. Several representatives from the prairie parks have contributed to a recovery plan draft, and the MWR restoration ecologist has been appointed as a working group member.

Monitoring of the federally endangered species, Missouri Bladderpod, provides another opportunity for linkage. Because the recovery plan for Missouri Bladderpod includes a monitoring component, FWS may be interested in the cooperative development of monitoring objectives and protocols for Missouri Bladderpod. TNC and Missouri Department of Conservation also own Missouri Bladderpod sites and could benefit from the development of a monitoring program.

The problems of external land-use and watershed changes, habitat fragmentation, and exotic encroachment are not unique to national parks, but are common problems shared by land managers throughout the Great Plains. Monitoring protocols aimed at these issues will be useful to federal and state agencies, and private organizations such as TNC, that manage small grassland preserves. These land managers could, in turn, allow NPS to use high-quality preserves as models for restoration of degraded NPS sites. The National Natural Landmarks could benefit and contribute to the monitoring program in a similar manner. Within the MWR, there are 15 NNL prairie sites, encompassing more than 4,400 ha. Other federal agencies, such as the Soil Conservation Service are involved with land use decisions involving natural resources in grassland regions. Such groups own or protect large acreage of land often in cooperation with other agencies. Under this proposal we will establish information exchange avenues with other land management agencies. Also, in situations where other agencies monitor lands near a cluster park we will establish cooperative agreements to share personnel and data.

We will propose that the cluster parks become participants in the Great Plains Initiative (GPI). Sponsored by the Western Governor's Association, the GPI is a collaborative effort to prevent the decline of species and the habitats they rely on for survival before they reach endangered status. The GPI is currently working to provide landowners, local communities, and all levels of decision makers with the information base, management tools, and institutional linkages to make more integrated, informed, and cost-effective natural resources decisions from the regional as well as the local perspective. We will propose the cluster parks be a pilot long-term monitoring site associated with the GPI. We believe information on the long-term sustainability of fragmented prairie will be of interest to the federal, state and local agencies and nongovernmental organizations that comprise the GPI.

XII. Reporting System

The results of the cluster park I&M program will be distributed to a wide range of audiences including all 32 prairie parks in the Great Plains. The following types of publications have been identified as potential outlets for I&M results:

1) An annual report will be produced that will document the progress of the I&M program. This will be a summary report providing a printout of the data collected during the year, basic data summaries, and a narrative detailing the progress of the program. The report will be published within one year after the completion of each field season.

2) The information summarized in number 1 above, as well as additional progress reports, will be communicated to the public through interpretive talks and publications and short informative articles published through local newspapers and popular magazines.

3) I&M protocols including methodology, techniques, and quality assurance requirements will be published through the NPS Publications Office.

4) The characterization of park resources and eventually the documentation of trends will be submitted for

publication in Park Science.

5) I&M results can potentially lead to uncovering new scientific information, the documentation of ecological cycles, and the validation of ecological theories. Any new scientific information resulting from I&M program would be published in peer reviewed articles in the appropriate scientific journals. The typical journals where some of the information would likely be published would be the Natural Areas Journal, Ecological Applications, The Prairie Naturalist, and Journal of Range Management.

6) I&M information would be disseminated through professional level meetings such is the George Wright Society Biannual Conference.

XIII. Threats to Park Resources

Small prairie park natural resource systems are threatened by habitat fragmentation and degradation from internal park developments and outside landuse and watershed changes. The long-term monitoring program proposed for prairie parks focuses on issues identified in a comprehensive survey of natural resources within parks in the Great Plains and the specific inventory and monitoring issues identified in park RMPs. The monitoring protocols developed or proposed relate to three high priority issues: 1) external threats, 2) ecosystem restoration and management, and 3) biological diversity.

Because small parks do not encompass the ecosystems they must manage, the impacts of external landuse and watershed use can be particularly severe. Altered water quality is the most immediate, external threat facing the cluster parks, and will be an early focus of monitoring. Urban encroachment, and concomitant habitat fragmentation, form another emphasis of this monitoring program, and will be monitored at the landscape, community and population levels. Urban encroachment and the resulting ecosystem disruptions are also closely tied to the sources and regulation of exotic and pest species. At present, altered air quality does not pose a serious threat to the cluster parks. This provides an opportunity to complete air quality baselines now so that the parks can serve as a benchmark against which future changes in air quality can be measured.

Diminished ecosystem integrity is the greatest internal threat to the prairie parks. Most of the Great Plains parks are small historic areas where prairie has only recently been treated as a principal resource. Habitat fragmentation, exotic encroachment, and an absence of fire threaten the integrity of these prairie resources. NPS managers are increasingly employing active resource management and restoration to address these threats. The proposed monitoring protocols will document the existing health and integrity of prairies ecosystems, and will provide feedback concerning the success of restoration and management actions.

The issues of external threats, and diminished ecosystem integrity are intertwined with the larger problem of conserving biodiversity. Monitoring protocols to address each of these issues have been proposed at the landscape, community and population levels. Employing protocols at several ecological scales will allow the full impact of threats to be assessed. It will also answer the question that small parks must address: To what extent are the species, communities and processes under their stewardship sustainable?

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APPENDIX A: A General Description of Cluster Parks

APPENDIX B: RMP Project Statements

Project Number	Project Title
AGFO-N-001	Research/Monitor Grasslands
AGFO-N-004	Initiate Water Quality Monitoring Project
AGFO-N-005	Survey Park Wildlife
AGFO-N-006	Develop Inventory & Monitoring Protocols
EFMO-N-001	Wetland Status Determination, Survey & Monitor
EFMO-N-002	Restore North Unit Prairie
EFMO-N-003	Manage & Restore Prairie/Savannah Remnants
EFMO-N-004	Restore & Manage Goal-Prairies
EFMO-N-005	Inventory & Monitor Exotic Plant Species
EFMO-N-005.001	Buckthorn Eradication
EFMO-N-005.002	Purple Loosestrife Cont'l
EFMO-N-009	Fauna Baseline Inventory
EFMO-N-009.001	Mollusk Study
EFMO-N-009.002	Reptile & Amphibian Inv.
EFMO-N-009.003	Mammal Survey
EFMO-N-009.004	Lichen/Bryophyte Survey
HOME-N-100	Restore Native Prairie
HOME-N-100.001	Prescribed Fire Program
HOME-N-100.002	Control Exotic Vegetation
HOME-N-100.003	Sod Transplant
HOME-N-100.004	Remove Non-Historic Trees
HOME-N-100.005	Freeman School Prairie
HOME-N-100.006	Monitoring Program
HOME-N-100.007	Transplant Rare Forbs
HOME-N-100.008	Old Hwy 4 Landscape
HOME-N-100.009	Thicket Control
HOME-N-100.010	Edge Management
HOME-N-100.011	Seeding Native Species
HOME-I-120	Monitor Visitor Information
HOME-N-120	Monitor Visual Quality of Prairie
HOME-N-200	Wildlife Management
HOME-N-200.001	Cavity Nesters Census
HOME-N-200.004	Baseline Inventory
HOME-N-300	Water Quality & Hydrology
HOME-N-300.001	Monitor for Public Health
HOME-N-300.002	Monitor Cub Creek
HOME-N-400	Monitor & Control Erosion
HOME-N-400.001	Control-Foot Bridge
HOME-N-400.002	Control-Southwest Bdry.
HOME-N-400.003	Upland Prairie
HOME-N-510	Monitor Meteorological Conditions
HOME-N-520	Air Quality Monitoring & Research
HOME-N-900	Deciduous Forest Baseline Data
PIPE-N-001	Prairie Monitoring
PIPE-N-003	Prairie Restoration Units 3 and 4
PIPE-N-004	Baseline Data Inventory
PIPE-N-005	Rare Plants Habitat Evaluations
PIPE-N-006	Rare Plant Map/Monitor
PIPE-N-007	Wetland Restoration, Management, and M o n
PIPE-N-008	Water Resource Monitoring
PIPE-N-011	Insect Survey
PIPE-N-014	Sumac Control/Monitor
PIPE-N-016	Aquatic Invertebrate Survey
PIPE-N-017	Monitor Fuel Load
PIPE-N-018	Plant Succession, Units 3 and 4
PIPE-N-21	Restore Native Veg./Old Ro ADBed and Visitor Center
PIPE-N-022	Remove Railroad Bed, and Replant Native
PIPE-N-024	Exotic Species Monitoring & Removal
PIPE-N-026	Air Quality Baseline Monitoring
SCBL-N-001	Mitigate Visitor Impacts-Summit Trail
SCBL-N-002	Prepare Historic Vegetation Study
SCBL-N-006	Monitor/Control Prairie Dog Population
SCBL-N-010	Monitor Air Quality Visibility
SCBL-N-012	Restore Native Prairie
SCBL-N-013	Study Role of Fire in Maintaining Prairie
SCBL-N-015	Develop Inventory & Monitoring Protocols
SCBL-N-015.001	Lichen
SCBL-N-015.002	Edge of Range Species
SCBL-N-015.003	Fish/Butterfly/Others
WICR-N-002	Initiate Baseline Inventory/Monitoring
WICR-N-009	Initiate Water Quality Monitoring Program
WICR-N-015	Conduct Historic Landscape Restoration

APPENDIX C: Park Scientific Studies and Surveys

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